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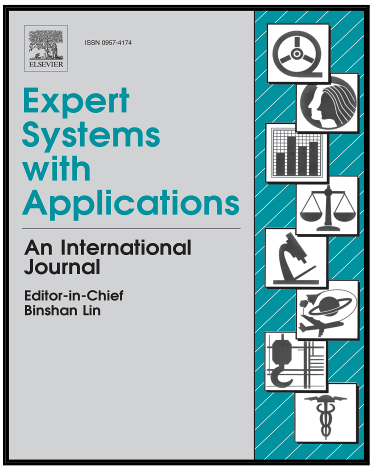

A three-stage DEA model to evaluate learning-teaching technical efficiency: Key performance indicators and contextual variables

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HIGHLIGHTS

- The main objective is to evaluate learning-teaching technical efficiency
- A three-stage Data Envelopment Analysis with contextual variables is used
- Super efficiency between efficient units is examined
- The key performance indicators and their influence have been identified
- The results also reveal that contextual variables are significant

A three-stage DEA model to evaluate learning-teaching technical efficiency: Key performance indicators and contextual variables

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Abstract

This study evaluates the technical efficiency of the learning-teaching process in higher education using a three-stage procedure that offers advances in comparison to previous studies and improves the quality of the results. First, it utilizes a multiple stage Data Envelopment Analysis (DEA) with contextual variables. Second, the levels of super efficiency are calculated in order to prioritize the efficiency units. And finally, through sensitivity analysis, the contribution of each key performance indicator (KPI) is established with respect to the efficiency levels without omission of variables. The analytical data was collected from a survey completed by 633 tourism students during the 2011/12, 2012/13 and 2013/14 academic course years. The results suggest that level of satisfaction with the course, diversity of materials and satisfaction with the teacher were the most important factors affecting teaching performance. Furthermore, the effect of the contextual variables was found to be significant.

Keywords: Learning-teaching technical efficiency, key performance indicators, contextual variables, Data Envelopment Analysis (DEA), super efficiency.

1.- Introduction

The efficiency of university higher education is crucial to the development and growth of countries. Specifically, the production of human capital and the creation of new knowledge are fundamental factors for national economies that must compete at an international level. Therefore, studies such as this one, determining which aspects of higher education should be improved in order to achieve greater efficiency, are quite useful.

Over recent years, the growing importance of undergraduate and post graduate degree studies in tourism in Spain has justified the analysis of teaching efficiency in tourism studies (considering the fact that between the academic course years of 1988/89 and 2008/09, two and a half times the students pursued tourism degrees during a period in which, overall, diploma and degree studies decreased by approximately 25%, National Institute of Statistics [INE, in Spanish], 2010). This work focuses specifically on the tourism degree of the University of Alicante (Spain) during the 2011/12, 2012/13 and 2013/14 academic course years.

The aim of this work is first, to evaluate the efficiency of the learning-teaching process in higher education, specifically in the tourism degree and second, to select the correct indicators that permit an adequate evaluation of the performance and efficiency of education. The identification and subsequent study of the variables used to monitor the progress and success of the teaching process (Key Performance Indicators, KPIs) is a fundamental issue. According to the expert systems perspective, the methodology used in this study facilitates and improves the identification and quantification of potential improvements in terms of reduction of resources and/or improvement in academic results.

Since the work of Charnes, Cooper and Rhodes (1978), Data Envelopment Analysis (DEA) has been widely used to analyze efficiency in diverse areas, specifically, in higher education. It is ideal for analyzing activities in sectors that require multiple resources in their production process in order to generate different types of products. Thus, DEA has become one of the most frequently used methods for determining which variables contribute to improving higher education performance (Joumady & Risk, 2005; Johnes, 2006a; Agasisti & Dal Bianco, 2009). DEA has enabled the assessment of the relative efficiency of the units in higher education institutions and has permitted the determination of which inputs and outputs contribute to the achievement of optimum performance.

The methodology selected for this study was implemented in three stages. First, the DEA method developed by Fried and Lovell (1996) and subsequently modified by Muñiz (2002) was applied. This method considers the contextual variables that affect the teaching process; second, super efficiency was analyzed, leading to the prioritization of the efficient units; and, finally, a sensitivity analysis was conducted to determine the contribution of each variable in terms of the efficiency level without the need to omit any variables. A significant theoretical contribution of this study is that it improves the manner in which the key variables were selected in previous studies on teaching efficiency using DEA, such as those by Montoneri, Lee, Lin and Huang (2011, 2012), since it takes advantage of the information provided by contextual variables, super efficiency and the influence of variables (KPIs) on technical efficiency.

This study has been organized as follows: Section 2 presents a literature review in order to support the selection of the analysis model and variables. Section 3 presents the methodological model to be justified and described. The data from the study is presented in section 4 and the results of the same are presented and discussed in section 5. Finally, section 6 offers our conclusions and suggests the main ideas that may be implemented in order to improve the learning-teaching efficiency analysis.

2.-Literature review on efficiency in higher education

Assessing the efficiency of higher education institutions is not a simple task given that these are complex organizations having multiple inputs and outputs (Abd Aziz, Janor, & Mahadi, 2013; Johnes, 2006b). Although efficiency in higher education has also been analyzed using parametric and OLS (Ordinary Least Square) regression methods (Johnes & Taylor, 1990; Zoghbi, Rocha & Mattos, 2013), ever since Johnes and Johnes (1993) the most widely used methodology have been frontier methods such as Data Envelopment Analysis (DEA).

The principal empirical works existing on efficiency in higher education using non-parametric methods, specifically, the DEA method, have been analyzed below. These studies use higher education institutions, universities, faculties, university departments or programs, among others, as units of evaluation. These works analyze efficiency in the field, both in terms of teaching alone (aside from other activities) and teaching and research jointly (Table 1). Although several works in the literature have analyzed efficiency solely from a research perspective (normally measured with the production and output of published articles and research projects) these are not the subject of this study (Johnes & Johnes, 1993; Athanassopoulos & Shale, 1997; Ng & Li, 2000; Castrodeza & Peña, 2002; Johnes & Yu, 2008; Agasisti, Dal Bianco, Landoni, Sala & Salerno, 2011).

Studies analyzing the efficiency of higher education, in terms of teaching, have considered this subject from a variety of perspectives. Some studies simply analyze the relative effectiveness of higher education institutions in a specific country (Glass, Mccallion, Mckillop, Rasaratmen & Stringer, 2006 and Johnes, 2006b in UK; Agasisti & Dal Bianco, 2006, 2009 in Italy; Abbot & Doucouliagos, 2003 and Avrikan, 2001 in Australia; and García Aracil, López Iñiesta & Palomares, 2009 in Spain). Other studies have made comparisons on an international level, considering higher education systems in different countries (Agasisti & Johnes, 2009; European Commission, 2009; Joumady & Ris, 2005). Furthermore, a number of works analyze the efficiency of higher education at the departmental, faculty or university program levels. These studies have been classified into two categories: those evaluating the relative efficiency of the various units assessed at the same university, such as Kao and Hung (2008) and Abd Aziz et al. (2013) and those analyzing the efficiency of departments or faculties of the same discipline at different universities in the same country, such as Besley (1995), Colbert, Levary and Shaner (2000), Chang, Chung and Hsu (2012), Flégl and Vltavská (2013) and Avilés, Güemes, Cook and Cantú (2015).

Clearly, these studies consider the efficiency of higher education from a broad perspective, yet only Chan et al. (2012) has considered efficiency in higher education in the tourism department. Our study, however, has a more specific purpose, as it attempts to analyze the teaching-learning process, an area that has only been considered by a few researchers. Specifically, Montoneri et al. (2011, 2012) use the DEA method to examine teaching efficiency in written English at the University of Taiwan. Methodologically speaking, our study offers a number of advances, as described in section 3.

In order to evaluate teaching performance in higher education, indicators (inputs and outputs) must be selected with care. Therefore, Chalmers (2008) offers an overview of the context in which teaching performance indicators have been used in higher education, providing information on the level of compliance with quality objectives in the teaching learning process and permitting comparisons to be made.

In the aforementioned works, it is clear that when assessing the efficiency of higher education institutions and providing guidance on educational policy, the most widely used variables for teaching outputs have been the number of undergraduate and postgraduate degrees awarded (Abbot & Doucouliagos, 2003; Johnes, 2006b), the number of equivalent full time students (Besley, 1995; Avrikan, 2001; Abbot & Doucouliagos, 2003), the number of graduates (Besley, 1995; Agasisti & Dal Bianco, 2006, 2009; García Aracil et al. 2009; Agasisti & Johnes, 2009; European Commission, 2009; Abd Aziz et al. 2013; Flégl & Vltavská, 2013), the percentage of students that gain employment (Avilés et al, 2015) and students´ learning performance (Montoneri et al, 2011, 2012).

As for inputs, the most frequently used teaching variables found in the literature were personnel, students and facilities and equipment. Regarding personnel, although most works distinguish between academic and non academic personnel (Avrikan, 2001; Abbot & Doucouliagos, 2003; Glass et al. 2006; García Aracil et al. 2009; Abd Aziz et al. 2013), some studies only consider academic staff, measured by the number of equivalent full time personnel (Johnes, 2006b; Agasisti & Dal Bianco, 2006, 2009; European Commission, 2009; Flégl & Vltavská, 2013), although personnel may also be measured in terms of salary costs, as in Besley (1995) and Flégl and Vltavská (2013). Montoneri (2011) looked at teaching skills**.** Another commonly used teaching input is the number of full time students (Agasisti & Dal Bianco, 2006, 2009; Johnes, 2006 b; Agasisti & Johnes, 2009; European Commission, 2009). In the case of students, their entrance characteristics are also taken into account with respect to the qualifications obtained (Joumady & Ris, 2005; Johnes, 2006a; Avilés et al., 2015). Colbert et al. (2000) look at the teacher/student ratio. Another commonly used indicator is that of facilities and equipment, normally in terms of cost (Besley, 1995; Glass et al. 2006; Johnes, 2006b; Agasisti & Dal Bianco, 2009). Montoneri et al (2012) examined the diversity of multiple teaching channels accessed and the diversity of teaching materials used.

A review of all of these works was necessary in order to determine the statistical model and variables to be used in our analysis, applied to higher education. A recapitulation of the aforementioned studies, methodology and indicators, is shown in Table 1.

[Table 1]

3.-Method

Based on the reviewed studies, this section presents the methodology used in our analysis, the inputs and outputs used and an outline of our reasons for selecting them.

The literature revealed that data envelopment analysis (DEA) was the most frequently used method for analyzing efficiency in the context of higher education, although other methods such as the Stochastic Frontier Analysis (SFA) have also been used. DEA offers a number of advantages that make it ideal for analyzing efficiency in higher education in general, and in teaching, specifically. First, it is ideal for the analysis of activities in sectors that require multiple resources in their production process in order to generate different types of products. Furthermore, this method does not require any type of information on the variable prices and therefore, it is ideal for situations where it is impossible to calculate these prices, or when computing them correctly would be difficult, as is the case with public education centres. In addition, DEA does not require the definition of a functional relationship between resources and products (as is necessary with other methods such as regression or SFA) since it is a non-parametric method that seeks to optimize the level of efficiency of each unit of analysis subjected to assessment (Decision Making Unit (DMU)) in order to create an efficiency frontier based on the Pareto criterion. Finally, this methodology allows for the use of non-discretional variables (which are not controllable by the manager) and offers specific information for each DMU regarding how to improve its efficiency level (Charnes, Cooper, Lewin & Seiford, 1997a).

Nonetheless, as with any other method, DEA has certain disadvantages. One of its main drawbacks is the need for homogeneity of the DMUs, which implies that the analyzed units should use the same types of resource, generating the same class of products and that the circumstances that contextualize the productive process should be similar (Cooper, Seiford & Tone, 2007). Secondly, it is a deterministic model. That is, it assumes that any resulting inefficiency is solely and exclusively due to the inappropriate management of the DMU, thereby ruling out any possibility of random influences. Finally, DEA demands that special care be taken in the selection of the variables to be included in the analysis given that there are no appropriate tests for their selection and evaluation of significance. Therefore, a review of prior studies carried out in this field was essential (Coelli, Rao, O´Donell & Battese, 2005). Despite its disadvantages, the advantages of DEA in analyzing teaching units, as explained above, are greater and more significant than any potential disadvantages. Therefore, and due to its use in similar studies, as described in the aforementioned bibliography, this methodology was selected for our study.

In short, DEA is a method based on obtaining an efficient frontier based on a set of observations. This frontier is obtained through the use of linear optimization programs in which the measurement of efficiency is defined as a ratio between the weighted sum of the outputs and inputs in each DMU. Said linear programs are defined in order to ensure that the weighting in each particular case is as advantageous as possible for the resulting efficiency measure (Charnes, Cooper, Lewin & Seiford, 1997b). Thus, a unit subjected to assessment shall be considered efficient when it uses a minimum amount of resources in order to obtain a specific level of production (input-oriented model) or, from a contrary perspective, when it obtains the maximum level of product based on a specific level of resources (output-oriented model). Due to the

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specific conditions characterizing public higher education funding in Spain, this study considers the second type of orientation (outputs). The Spanish public higher education system tends to be state-funded, with the state transferring funds to the universities which subsequently determine how they are to be administered in order to obtain the best possible results. Thus, given the level of resources, the goal is to achieve the maximum possible level of output (as established in the second option described above).

In the efficiency analysis, it is necessary to determine the type of efficiency to be evaluated. The most commonly-used type of efficiency in higher education according to the literature, is technical efficiency, despite the fact that, at times, other types (such as economic or allocative) have also been considered. Technical efficiency is a reflection of the efficiency obtained by the DMUs in terms of the quantities of outputs produced in comparison to the inputs used, while allocative efficiency also considers information provided by the prices of the resources. Finally, economic or overall efficiency is the result of the product of the first two (Bojnec & Latruffe, 2008). In this study, the absence of information on prices of both the teaching service provided as well as the resources used, due to the public nature of the education process, justifies the selection of technical efficiency as the most appropriate method, since it does not require these types of data for its calculation. It should also be noted that technical efficiency is defined as a measure of the degree of perfection to which a DMU uses its resources in order to obtain outputs in comparison with its maximum potential. Thus, only physical variable units are involved, with there being no need to use prices, as would be necessary in order to compute allocative and overall efficiency (Barros & Mascarenhas, 2005; Fuentes & Lillo-Bañuls, 2015).

Furthermore, the DEA model applied was based on the characteristics of the teaching groups under analysis (DMUs). So first, since they are subject to the same institutional and teaching context and depend on equivalent funding, it was not deemed appropriate to consider the existence of any type of variable returns to scale and a prevalence of constant returns was assumed. These are homogeneous groups, as described in section 4, and therefore, no differential factor could cause any of them to have advantages over the others. Thus, the guidelines established by Charnes, Cooper, and Rhodes (1978) (CCR), which generated the DEA model type that assumes the existence of constant returns to scale (CCR model), were followed in this study. According to this perspective, the linear program used to obtain the level of efficiency of each DMU was:

$$\begin{aligned}
&Max_{\phi_o,\,\lambda,\,S^+,\,S^-} \quad \phi_o + \varepsilon\left(\sum_{i=1}^{I} S_i^- + \sum_{r=1}^{R} S_r^+\right)\\
&s.t.\\
&\sum_{j=1}^{n} \lambda_j \cdot Y_{rj} - S_r^+ = \phi_o Y_{ro}, \forall r = 1 \ldots R \qquad (1)\\
&\sum_{j=1}^{n} \lambda_j \cdot X_{ij} + S_i^- = X_{io}, \forall i : 1 \ldots I\\
&\lambda_j, S_i^-, S_r^+ \geq \varepsilon \succ 0
\end{aligned}$$

where ϕ_o is the parameter that measures the efficiency of the unit analyzed (the sub index $_o$ refers to the assessed DMU, o:1,...,n); n is the total number of DMUs analyzed, j=1,...,n; Y_{rj} is the r-th output of the j-th DMU, r=1,...,R, j=:1,...,n; X_{ij} is the i-th input of e j-th DMU, i=1,...,I, j=1,...,n; λ_j is the weight obtained as a solution to the program which express the weight of each DMU in the peer group of the DMU_o; S_i^- are slack variables for inputs (expressing the amount of inputs that should be reduced in order to obtain the optimal level of efficiency for the unit analyzed); S_r^+ are slack variables for outputs (expressing the additional amount of outputs that should be increased after increasing all of the outputs by (ϕ_o -1) in order to achieve its maximum level of efficiency – a DMU is efficient when $\phi_o = 1$ and the values of S_i^- and S_r^+ are 0 -) (Cooper, Seiford, & Tone, 2007); ε is a small positive real number (usually, in empirical calculations, 10^{-6}) (Norman & Stoker, 1991).

From (1), the total slack values for each discretionary input and output are obtained:

$$S^{T}{}_i^- = S_i^-$$
$$S^{T}{}_r^+ = (\phi_o - 1)\, Y_r + S_r^+$$

Second, it was considered important to include the influence of contextual (non-discretionary) variables. The information included with these variables reflects upon different characteristics that are beyond the control of the managers but that may influence the levels of efficiency of the evaluated units (Muñiz, 2002). The selection of a DEA model with contextual variables was based both on prior studies that included these variables to analyze efficiency in higher education (Joumady & Ris, 2005; Jones, 2006a and Agasisti & Dal Bianco, 2009, etc.) as well as on the possibility of having information on the same. Specifically, the method developed by Fried and Lovell (1996), subsequently modified by Muñiz (2002) was considered. The use of this model was justified, both due to its ability to adapt to the characteristics of the education sector, as previously demonstrated by Muñiz (2001), and due to the advantages presented in comparison to other models including contextual variables (such as Banker & Morey, 1986; Ruggiero, 1998 and Yang & Paradi, 2003). Specifically, these advantages include offering better results and not requiring functional forms and/or ad hoc parametric values in any of the three stages necessary for the calculation of the efficiency stages. Thus, the model is coherent with the theoretical foundations of DEA (Muñiz, Paradi & Ruggiero, 2006). Finally, the decision regarding the type of DEA model with contextual variables to be used was also based on the criteria of understability, applicability and acceptability, as suggested by Huguenin (2015).

The selected method (Muñiz, 2002) considers the assessment of each unit in three phases. In the first phase, the existence of the contextual variables is unknown when conducting the analysis. Therefore, the linear program (1) is solved, returning the efficiency index and the slack variables for each input and output.

In the second phase, the contextual inputs are considered. In this stage, the goal is to minimize the slack variables given the values of the contextual inputs. This may be obtained using the following linear program:

$$Min_{\beta_0, \lambda, S'^{+}, S'^{-}} \quad \beta_o$$

$$\begin{aligned}
&S.A \\
&\sum_{j=1}^{n} \lambda_j \cdot Z_{mj} - S'_m{}^{-} = Z_{mo}, \forall m : 1 \ldots M \\
&\sum_{j=1}^{n} \lambda_j \cdot S^T{}_{ij}{}^{-} + S'_i{}^{-} = \beta_o \cdot S^T{}_{io}{}^{-}, \forall i : 1 \ldots I \\
&\lambda_j, S'_i{}^{-}, S'_m{}^{-} \geq \varepsilon \succ 0
\end{aligned} \tag{2}$$

where Z_{mj} is the m-th contextual input (non-discretionary) of the j-th DMU, m=1,...,M, j=1,...,n; S_{ij}^{-} are total slacks for inputs calculated in the first phase for each DMU_j in input X_i; $S'_m{}^{-}$ and $S'_i{}^{-}$ are slack variables for contextual (non-discretionary) inputs and total slacks, respectively.

The previous program would be similar for Y_r except for the total slack which would be: $S^T{}_r{}^{+} = (\phi_o - 1)\, Y_r + S_r^{+}$. Now, the original values of the discretionary inputs and outputs are modified by the effect of the contextual inputs (Muñiz, Paradi, Ruggiero & Yang, 2006) as follows:

$$X_i^* = X_i - \beta_o \cdot S^T{}_i{}^{-},\ i:1,\ldots,I$$
$$Y_r^* = Y_r + S^T{}_r{}^{+},\ r:1,\ldots,R$$

Then, in the third phase, the previous modified values (X_i^*, Y_r^*) are used to obtain the definitive results by once again using the linear program (1).

Finally, apart from the constant returns to scale and the aforementioned contextual variable model, a final additional variant of DEA was introduced in order to avoid ties in the coefficients of the DMUs resulting from the analysis. In fact, all of the efficient DMUs always obtain a resulting efficiency coefficient that is equal to the unit. In this way, all of the efficient units achieve the same level of evaluation (the unity) without it being possible to distinguish between them. However, by applying the super efficiency model developed by Andersen and Petersen (1993) it is possible to achieve a prioritization of the efficient units and therefore to determine which is best assessed by the model, enabling more detailed conclusions to be drawn. The linear program of this model is:

$$
\begin{aligned}
& Max_{\phi'_o, \lambda, S^+, S^-} \quad \phi'_o + \varepsilon\left(\sum_{i=1}^{I} S_i^- \quad + \sum_{r=1}^{R} S_r^+\right) \\
& s.t. \\
& \sum_{j=1, j\neq o}^{n} \lambda_j \cdot Y_{rj} - S_r^+ = \phi_o Y_{ro}, \forall r = 1 \ldots R \\
& \sum_{j=1, j\neq o}^{n} \lambda_j \cdot X_{ij} + S_i^- = X_{io}, \forall i : 1 \ldots I \\
& \lambda_j, S_i^-, S_r^+ \geq \varepsilon \succ 0
\end{aligned}
\tag{3}
$$

where the evaluated DMU_0 is now omitted from the left side of the restrictions and ϕ'_o is the super efficiency value.

Apart from the previous, once the results were obtained, they were subjected to a sensitivity analysis based on calculation of the contribution of each variable to the efficiency level of each unit assessed without the need to drop any variable of analysis, thereby preventing the bias that may go along with the calculation of efficiency levels (Coelli, Rao, O´Donell & Battese, 2005). The purpose of this was to identify those variables having the greatest influence on teaching efficiency, so as to focus attention on them as KPIs (as it is detailed later in section 5).

Overall, it is clear that the specific method of analysis proposed in this study offers advances with respect to prior studies having the same purpose (such as Montoneri et al., 2011; Montoneri et al., 2012), since it includes information regarding the contextual variables, makes an evaluation of the levels of super efficiency and carries out the sensitivity analysis in order to identify the KPIs, based on the influence of each variable that is directly offered by the model, without the need to drop any variables.

Another important decision when carrying out this research was the choice of variables for consideration, which were selected based on the literature available on this type of analysis (Barros & Matías, 2006). Having reviewed the literature on efficiency of the teaching-learning process, it was clear that, despite the diversity of variables chosen in existing works, the selection of inputs tended to focus on concepts relating to the skills of the teaching staff, quality and diversity of materials and abundance of teaching contents (Montoneri et al. 2011; Montoneri et al. 2012). Contextual factors that could also affect the level of student performance have also been studied, as in Joumady and Ris (2005) and Johnes (2006a), who include student grades on university entrance exams in their inputs. On the other hand, variables used as outputs tend to focus on grades, teaching staff attitudes, student learning performance, student levels of satisfaction with the courses and student interest (Montoneri et al. 2011; Montoneri et al. 2012).

In this study, in terms of inputs, we considered both contextual (non-discretionary**)** variables as well as variables of a magnitude that may be altered by the manager of the unit under analysis (discretionary variables). Furthermore, the fact that the variables chosen as inputs will have a direct relation to the outputs in accordance with the principle of isotonicity was taken into account, as we shall demonstrate below. Specific variables used in this research are:

Discretionary inputs: I_1, satisfaction with the teacher or lecturer (degree of student satisfaction with the teaching staff in terms of quality of explanations, communicative ability and level of knowledge demonstrated); I_2, quality of teaching materials (the students' opinion regarding the clarity and quality of content of the teaching materials used); and I_3, diversity of teaching materials (level of complaisance shown by students with the range of teaching materials offered and the possibilities of accessing the same).

Contextual inputs (non-discretionary): I_4, socio-economic and cultural level of students' families (social and cultural level of the family background); and I_5, students' education prior to university (student academic results during secondary education).

Outputs: O_1, students' level of satisfaction with the course (students' opinion on general planning and future validity of the course at a professional level); and O_2, academic results of students (qualifications obtained by students at the end of the course).

4.-Data

The data required for the analysis was obtained from the 2011/12, 2012/13 and 2013/14 academic course years, during which a survey was completed by students in the "Practical Introduction to Economics" course held during the first year of the Tourism degree program at the University of Alicante (Spain). The course is designed to familiarize students with theoretical and practical concepts of economics applied to the tourism industry.

633 students completed the survey, supposedly all of the students registered in this degree program for the first three academic terms analyzed, given that the survey was conducted in the class and classroom attendance is mandatory. As part of the process, questionnaires that did not contain minimum quality criteria were discarded, in order to ensure the reliability of the results. 91.3 % of the surveys collected were considered valid.

The survey contained a total of 12 questions with a scale of 0 (the worst) to 5 (the best). The first ten questions coincide with those suggested by the National Agency for Quality Assessment (ANECA) and are officially worded by the Quality Department of the Vice Rectorate of Studies, Education and Quality of the University of Alicante to evaluate the teaching activity of its professors on a quarterly basis. This decision was justified by the fact that this is a widely accepted and contrasted survey in the Spanish university environment and it was created by official organisms that are related to the area of quality in Spanish higher education (ANECA). Also, based on the information collected from the same, it was possible to access data regarding the variables that past research has identified as being inputs and outputs for inclusion in the analysis model. Two additional questions related to the socio-economic and cultural contexts of the students were added in order to include contextual variables in the model.

Each of the groups in this course was used as a reference for analysis (DMU). Specifically, each academic year under analysis included 24 groups taught by a full time lecturer having a one hour class every week (legally established to this effect). The 24 groups are pre-defined by the Vice Rectorate of Academic Planning of the University of Alicante prior to the beginning of each academic term. They are homogeneous groups with identical characteristics in terms of size, type and quality of infrastructures. The number of groups provides sufficient margin to use 7 variables in the study, given that the number of DMUs analyzed must be three times greater than the variables used. Otherwise the discriminatory power of the DEA model would be questionable (Cooper et al., 2007). In our case, tripling the variables would result in 21 (less than the DMUs that are actually used (24)), therefore this requirement has been clearly fulfilled.

[Table 2]

As mentioned above, the principle of isotonicity was also fulfilled since, as revealed in table 2, the Pearson correlation test has confirmed this. All of the correlation values were significant, ranging from 0.64 to 0.86, thereby indicating a high correlation level and confirming that the aforementioned principle required by DEA was duly fulfilled.

5.-Results

The objective of this section is to describe and comment on the results obtained from the application of the previously described method (seen in section 3). All of the results of the efficiency analysis were obtained using Lingo 12.0 software and these results appear in Table 3.

[Table 3]

The first two columns of Table 3 reflect the groups (DMUs) and the academic course (Period). Then, column three indicates the efficiency values of each group having four values per cell. The first three values refer to the academic years and the final value refers to their average value (this same order is followed for the remaining columns in the table). Since the DEA model used is output-oriented, all of the values in this column may be greater than the unit (inefficient), equal to the unit (efficient) or lower than the unit (super-efficient). For the super-efficient DMUs, the difference from the unit reflects their degree of importance within the efficient group. Specifically, the greater the difference from the unit, the greater the degree of super efficiency and importance. In Table 3 we observe that the number of super efficiency units increased from five in the 2011-12 course year to nine in the 2013-14 term, such that the results reveal a positive evolution in number of groups achieving the optimal efficiency level.

In the case of inefficiencies, the difference with the unit indicates the level of inefficiency or the percentage increase in level of outputs that the group would have to experience in order to become efficient. Therefore, the greater the value, the more inefficient the DMU. For example, the efficiency value of the DMU 4 for the 2011-12 course year was 1.183, suggesting 18.3% inefficiency. This means that group 4 would need to have increased its level of output by 18.3% in order to have been efficient (Charnes et al. 1997a). However, this would not be the only action to this effect, since it would require additional measures in order to achieve efficiency, as explained below in the discussion of the meaning of the following columns in Table 3. Specifically, from column 4 to 8, the values obtained are compiled for the slack variables of each discretionary input and output as percentages of the initial levels of the same. Thus, those figures refer to the percentage by which each discretionary input should be reduced in order to attain efficiency and, in terms of outputs, the percentage of each one that should be added to that which was already added by the result of inefficiency so that the DMU could become efficient. That is, and based on the previous example, with respect to DMU 4 in the 11-12 course, apart from the increase in all of their outputs by 18.3% as already mentioned, their academic results would have also needed to have improved (O_2 = 3.68%), while the teacher's teaching efforts should have been less intense (I_1 = 1.61%). In this case, the additional effort in the O_2 should be more than twice as intense as the reduction of effort in I_1, indicating the importance of modifying the level of O_2 so that group 4 attains the level of efficiency during the 2011-12 course (Cooper, Seiford & Zhu, 2004).

In addition to the previous information, Table 3 also presents the results of the contribution of each variable to the efficiency of each group or, in other words, the results of the sensitivity analysis of the model given the variations in their levels. These results are shown in columns 9 to 13. So, the greater the value, the greater the relative influence of the variable on the level of efficiency. For example, for the case of unit 4 in the 2011-12 course year, it was noted that diversity of teaching materials (I_3 = 0.38) was the variable that, relatively speaking, had the greatest effect on efficiency level, followed by level of satisfaction with the course (O_1 = 0.24).

The final column of Table 3 shows the percentage influence of the contextual variables on the efficiency levels of each group. This result was obtained by comparing the results of efficiency when including contextual information with the results when this information is not included (rate of change). Therefore, they reveal how the students' contextual conditions influenced the results. In the case of DMU 4 for the 11-12 course, this effect was 3.01%. In other words, the contextual factors improved the efficiency of the DMU 4 by 3.01%.

This individual analysis of each of the DMUs may be completed with a general analysis (final row of Table 3), in order to obtain information on the aggregated behavior of the analyzed class groups. This data allows for the identification of both the variables that should be improved in order for the inefficient groups to no longer be so, as well as the variables that have contributed the most in relative terms of achieving global efficiency levels. Thus, the results of columns 4 to 8 of the last row of Table 3 highlight that, generally speaking, the main strategy to improve the inefficient groups should be directed at improving the level of academic results (O_2=0.74). Similarly, the results from columns 9 to 13 of the last row of Table 3 reveal that the level of satisfaction with the course (O_1=0.20) was key, followed by diversity of materials (I_3 =0.13) and satisfaction with the teacher (I_1=0.11), although the level of relative importance between the inputs was not very disparate. According to this perspective, efforts should be made to improve levels of the O_1 variable, while also paying attention to the inputs, with I_3 being the most important of these.

Thus, this aggregate information allows us to establish patterns of global action that may generate both reductions in the levels of inefficiency of the detected groups as well as improvements in the use of available resources, permitting an improved and more efficient use of the same.

It is also relevant to reach conclusions regarding the influence of each variable over time. According to the average data from each of the academic course years, it is found that, while the importance of quality of teaching materials (I_2) and diversity of materials (I_3) decreased between 2011/12 and 2013/14, the importance of satisfaction with the teacher (I_1) increased. In other words, over time, the students placed an increased importance on satisfaction with the teacher as compared to quality and diversity of materials, despite the fact that, as previously noted, diversity of materials continues to be the most influential input.

This result may be justified by the fact that the channels through which the materials are presented to students may have reached levels that could not be improved. Currently teachers use many physical and virtual methods available in various formats in order to ensure that students have easy access to materials. Furthermore, the content of the materials is adapted and renewed for each academic course in order to improve and update information. Thus, the lecturer's teaching skills and interactive strategies, being approachable, communicative, motivational, solicitous and clear is the main factor on which the students could focus their opinions for improvement.

Despite this, in order to confirm these results, discussion groups were formed and the students in the most efficient groups were interviewed. The interviews were conducted with an open response format and were conducted in their teacher's office. Students were encouraged to voluntarily offer their opinions on which factors could be identified as being the most important in order to improve efficiency of the groups (without the interviewer specifying any variable) and to provide their opinions regarding why other factors were not as influential, in their opinion.

The responses obtained from these groups were provided from 65% of the students from the three best groups (DMU 23 of the 2013/14 course, DMU 2 of the 2012/13 course and DMU 24 of the 2011/12 course, respectively). The majority of the interviewed students concurred with the indicated motives and factors. Specifically, issues such as clarity of explanations, attention provided by teachers and their willingness to resolve problems, prevailed over aspects such as the level of qualifications, the content of materials or the means by which these could be achieved or used, thus corroborating the ideas obtained by the DEA data analysis.

Regardless, it is necessary to understand that improving student satisfaction with their teacher is frequently conditioned by the particular nature of the tasks undertaken by the teacher. So, improving this aspect is something that should be included in the proposals of any scientifically robust expert systems framework. In this way, it is clear that certain aspects condition teaching ability as mentioned in literature on the subject. Specifically, teacher workload, dedication to research, performance of administrative tasks or level of previous experience are characteristics that influence the teaching abilities of university staff (De Witte, Rogge, Cherchye & Puyenbroeck, 2013).

In summary, the results obtained from the application of the described model allow the managers to detect the inefficient groups and implement strategies for their improvement, as well as to implement plans of global action designed to increase teaching effectiveness in educational institutions over the long term. Therefore, this method may be used for quality control in higher education, offering a new perspective on how to link with data in order to improve teaching-learning outcomes.

6.-Conclusions

This paper examines teaching efficiency in higher education based on Data Envelopment Analysis (DEA) methodology. It has dual objectives: first, to examine the performance of students' educational process in tourism degree courses, and second, to attempt to identify the KPIs that may help to optimize the quality of the teaching process.

Based on expert and intelligent systems, the identification procedure for KPIs proposed in this study offer advances as compared to past research for a variety of reasons. First, it includes the effect of contextual variables when making the calculation of values of efficiency using the DEA model designed by Muñiz (2002), having clear advantages over alternative models as discussed in section 3. Second, there is differentiation between efficient DMUs based on the calculation of super efficiency values. And finally, the influence of each discretional variable is determined based on the efficiency levels using the information provided by the model, without the need to drop any of these variables, which, generally speaking, artificially alters the calculation of the efficiency values, and therefore, the identification of the KPIs. These theoretical advantages result in an advance in the identification of the most relevant KPIs (based on the analyzed situation) given that they include all of the information extracted from the studied DMUs and therefore, avoid any type of bias that may result from either a lack of information or the use of calculation methods that may intrinsically lead to errors.

Among the principal results obtained, the following variables were highlighted as the most important: level of satisfaction with the course, diversity of materials and satisfaction with the teacher with the latter developing greater importance over time. It was also observed that the effect of the contextual variables was positive and improved efficiency by 0.91% on average.

The methodology utilized in this work and its application to higher education allows for the improved control of educational quality, with the data obtained from students serving to detect inefficiencies in individual units and to improve global results. It is also of interest for educators interested in improving the teaching-learning process and the results of their students.

Despite the contributions of this research, the procedure used presents certain limitations. On the one hand, a dynamic model was not used. Thus, despite including information from various years, this study cannot be generalized, but should be considered for the calculation of efficiency for each of the academic years of the 2011-2014 period. From a dynamic point of view, the treatment of the information would allow for additional results that could strengthen the conclusions. Another limitation is that the calculation of the efficiency levels were made without using methods to identify the outliers, which may introduce bias in the calculation of efficiency for the remainder of the DMUs as they present excessively isolated levels of efficiency (either because the information regarding the inputs and outputs does not coincide with the real situation due to causes that are not controllable by the managers, because they present advantages of functioning that are not accessible to the rest of the DMUs or for both reasons).

Therefore, future studies should seek to prevent these limitations, treating the information in a dynamic manner using specific models (such as, for example, DEA-windows) and should consider the treatment of outliers, either previously, using specific algorithms (such as, Wilson, 1993 or Simar, 2003) or through models with intrinsic treatment (such as those based on order-*m* efficiency).

However, there are theoretical alternatives that, despite the limitations of the model, may also be considered in order to advance future studies. For example, the treatment of the contextual variables within the DEA models based on conditional order-*m* efficiency (COE) may permit the analysis of the significance of these variables with respect to the efficiency levels found, thereby revealing whether or not it may truly be considered a KPI (assuming that it is possible to have the information for a sufficiently high number of DMUs so as to use this type of COE model). Furthermore, COE also allows for the introduction of information from discrete variables and, in this way, to add new and additional information that may be relevant for the calculation of the efficiency parameters and therefore, the selection of KPIs.

Finally, this work analyzes a topic of interest for higher education administrators and teachers who are interested in improving their practices through the DEA model. Thus, this paper provides a framework of reference for application to future research, exploring an analysis of indicators that contribute to learning and teaching performance. The methods used in this study may be extrapolated to students of other degree areas, universities and countries, thus making a significant contribution to the improvement of learning-teaching efficiency in higher education.

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Table 1

Review of the methodology and indicators analysing efficiency in Higher Education (teaching) with efficiency frontier applications

Author(s)	**Methodology**	**Scope of analysis**	**Indicators** **INPUT**	**Indicators** **OUTPUT**
Besley (1995)	DEA Oriented to output CRS	Teaching +Research (analysed separately)	I1: General costs (staff salaries) 12: equipment and facilities cost - I3: Research rent	O1: No. degree students O2: No. teaching post graduates O3: no. research postgraduates O4: publications and citations O5: whether the department is outstanding; above average, within the average, or below average in research
Colbert et al. (2000)	DEA Oriented to output VRS	Teaching	I1: teacher/student ratio 12: average GMAT value of students in the programme 13: average no. of years of work experience of students on the programme 14: average GMAT score 15: no. options	3 Output series: 1. They measure the students' satisfaction: % students, satisfaction with teaching, with the curriculum, with the site. 2. They measure satisfaction of those recruited: average initial salary, satisfaction with the analysis, with the team and with their view of the world. 3. Outputs that measure both
Avrikan (2001)	DEA Oriented to output VRS	<u>Model 1</u>: Teaching +Research <u>Model 2</u>: Teaching <u>Model 3</u>: Paid teaching	MODEL 1, 2, and 3: 11: academic personnel (FTE) 12: non-academic personnel (FTE)	MODEL 1: O1:undergraduate enrolments (FTE) O2: Postgraduate enrolments (FTE) MODEL 2: O1: student retention rate (%) O2: Student progress rate (%) O3: Graduates (FTE) MODEL 3: O1: Overseas fee-paying enrolments O2:Non-overseas fee-paying postgraduate enrolments
Abbot and Doucouliagos (2003)	DEA Oriented to input VRS	Teaching +Research	11: no. academic personnel (FTE) 12: no. of non-academic personnel 13: other costs	O1: no. of students (FTE) O2: no. first degree and postgraduate registrations O3:no. postgraduate qualifications awarded

Author(s)	Methodology	Scope of analysis	Indicators INPUT	Indicators OUTPUT
				O4: no. graduate qualifications awarded
Joumady and Ris (2005)	DEA Oriented to output VRS Cluster	Teaching	Those of model 1 are presented: 11: entry characteristics of students (entrance qualification, entrance grade) 12: human and physical capital (teaching characteristics, library equipment, teaching material available, technical equipment -pc-, course content, practical emphasis of teaching and learning)	Those of model 1 are presented: O1: level of acquired vocational competence O2: level of generic acquired competence
Agasisti and Dal Bianco (2006)	DEA Oriented to input CRS and VRS 26 models	Teaching + Research	I1:average no. of teachers 2001-2003 I2: total no. of students. 2002 /2003 academic year I3: Public funds in 2003 14: no. "regular" students 2002/2003 Academic year	O1:no. of graduates in 2003 O2: national research periods (average for the period): O3: external assistance with research O4: no. of educational credits obtained. 2002 /2003 academic year
Glass et al. (2006)	DEA Oriented to input Oriented to output VRS	Teaching +Research	11: academic personnel (FTE) I2: Other personnel (FTE) I3: research grants (pounds per academic personnel) I4: Capital costs (pounds per student)	O1: Research (adjusted to quality) O2: no. of students (FTE) (adjusted to quality)
Johnes (2006 a)	DEA Oriented to output VRS	Teaching	I1: students' academic results prior to university 12: personal characteristics	O1: graduate results
Johnes (2006 b)	DEA Oriented to output CRS and VRS	Teaching +Research	I1: no. of first degree students (FTE) I2: no. of postgraduate students (FTE) 13: no. academic personnel (FTE) 14: depreciation and interests payable I5: Cost of libraries and information services I6: Central administrative costs	O1: no. of degrees obtained O2: no. postgraduates O3: Research grants
Kao and Hung (2008)	DEA Oriented to output VRS Cluster	Teaching +Research	I1: personnel 12: costs 13: space	O1: total of credit hours: teaching workload O2: publications O3: external grants
García Aracil, et al. (2009)	Malmquist index (non parametric) Oriented to output CRS and VRS	Teaching +Research + Knowledge transfer	I1: Total cost 12: academic personnel 13: non-academic personnel (teaching practice, research and knowledge transfer are considered)	O1:no. of graduates (proxy research) O2: publications (proxy research) O3: total amount of applied research (proxy transfer of knowledge)

Author(s)	Methodology	Scope of analysis	Indicators INPUT	Indicators OUTPUT
Agasisti and Dal Bianco (2009)	DEA Oriented to output CRS and VRS Malmquist index	Teaching	11: no. of registered students per university 12: total no. registered with an average grade exceeding 9 in secondary education I3: total no. of regular students. I4: total no. of students. 15: no. academic personnel (FTE) 16: Structure (no. of places available in classes, libraries and laboratories)	O1: total no. of graduates per university O2: total no. of graduates in 4 or 5 year courses per university
Agasisti and Johnes (2009)	DEA CRS and VRS	Teaching +Research	I1: Total number of students. I2: the total amount of financial resources/incomes I3: Number of PhD students I4: Number of Academic staff	O1: No. of graduates (bachelor + master) O2: total amount of assistance and external contracts for research
European Commission (2009)	Semi-parametric model (DEA and regression) SFA (stochastic frontier analysis)	Teaching +Research	I1: academic Staff (FTE) I2: Students in Institutions of tertiary education (FTE) I3:Total expenditure on Institutions of tertiary education in % of GDP I4:Total expenditure on Institutions of tertiary education in purchasing power standard in real terms per capita I5:Total public expenditure on tertiary education (public and private) (annual) I6: Total public expenditure for educational institutions (tertiary education)	O1: Students in Institutions of tertiary education (FTE) O2: Classification of world universities according to results from a survey concerning the employability of graduates O3: Classification of world universities according to results from a survey completed by academics from all over the world O4: Published articles. O5:Citations
Montoneri et al. (2011)	DEA Oriented to output. (CCR and BCC models)	Teaching	-I1: the preparation of teaching contents -I2: teaching skills	-O1: fair grading -O2: students' learning performance
Chang et al (2012)	DEA Two-stage model Oriented to output	Teaching + Research	I1:The number of full-time teachers (including professors, associate professors, assistant professors and lectures) I2: Operating expenses I3:Usablke departmental space I4:Number of books owned by department	First-stage: R&D Performance: 1:Number of teachers certifications 2:Number of publications 3: Project funding Second-stage teaching performance 1: Number of students certifications 2: Achievements of students in competitions 3: Employer satisfaction with graduate ability
Montoneri et al. (2012)	DEA Oriented to Output CCR model	Teaching	I1:The wealth and diversity of course contents (diversity of teaching materials) -I2:The diversity of accessed multiple teaching	-O1:The positive degree of teaching attitude -O2:Student´ learning performance

Author(s)	Methodology	Scope of analysis	Indicators INPUT	Indicators OUTPUT
			channels	
Abd Aziz et al. (2013)	DEA Oriented to input CRS 4 models with input and output combinations	Teaching +Research	11: academic personnel 12: non-academic personnel 13: annual operating expenditure	O1: number of graduates per annum O2: research grants received per annum O3: number of academic publications
Flégl and Vltavská (2013)	DEA Index approach	Teaching +Research	I1: real average salary 12: average no. academic personnel I3: average no. of students: bachelor + master	O1: average no. of graduates: bachelor + master O2: RIV (research, development and innovation) points
Avilés et al (2015)	DEA Time-staged outputs model Oriented to output VRS	Teaching	I1: academic rating I2: admission rating I3:financial rating I4: percentage of students who graduated in the top 25% of their class	O1: Students with internships O2: Job placement

GMAT: Graduate management admission test; FTE: full time equivalent; CRS: Constant returns to scale; VRS: variable returns to scale; HEI: higher education institutions.

Table 2. Pearson correlation coefficients between inputs and outputs*

OUTPUTS	COURSE	INPUTS				
		I_1	I_2	I_3	I_4	I_5
O_1	**11-12**	0.80	0.81	0.71	0.80	0.75
	12-13	0.86	0.80	0.79	0.68	0.77
	13-14	0.64	0.64	0.64	0.69	0.67
O_2	**11-12**	0.84	0.79	0.71	0.83	0.84
	12-13	0.78	0.77	0.69	0.71	0.82
	13-14	0.72	0.67	0.73	0.69	0.68

Note: I_1: Satisfaction with the teacher; I_2: Quality of materials; I_3: Diversity of materials; I_4: Socio-economic and cultural level; I_5: Previous education O_1: Level of satisfaction with the courses; O_2: Academic results

* implies a level of significance to 99%.

Table 3. Levels of efficiency, possibilities for improvement and influence of variables.

DMU	**Period**	**Level of efficiency**	**% possibilities for improvement**					**Contribution of each variable to the efficiency value**					**% influence of context variables**
			I_1	**I_2**	**I_3**	**O_1**	**O_2**	**I_1**	**I_2**	**I_3**	**O_1**	**O_2**	
1	**11-12**	1.023	3.40	0.94	0.00	0.00	0.00	0.00	0.00	0.47	0.23	0.05	2.36
	12-13	0.961*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.32	0.00	0.00
	13-14	0.994*	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.09	0.26	0.03	0.00
	Average	0.993	1.13	0.31	0.00	0.00	0.00	0.07	0.00	0.31	0.27	0.04	0.78
2	**11-12**	1.065	2.30	0.00	0.23	0.00	0.00	0.00	0.45	0.00	0.19	0.09	0.35
	12-13	0.906*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.34	0.00
	13-14	0.980*	0.00	0.00	0.00	0.00	0.00	0.28	0.03	0.00	0.10	0.19	0.00
	Average	0.984	0.77	0.00	0.08	0.00	0.00	0.10	0.16	0.13	0.10	0.21	0.12
3	**11-12**	0.999*	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.40	0.24	0.00	3.53
	12-13	1.010	0.00	0.00	0.00	0.00	0.00	0.16	0.14	0.01	0.25	0.05	0.05
	13-14	0.998*	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.21	0.17	0.08	1.50
	Average	1.002	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.21	0.22	0.04	1.70
4	**11-12**	1.183	1.61	0.00	0.00	0.00	3.68	0.00	0.04	0.38	0.24	0.00	3.01
	12-13	1.002	0.00	0.00	0.00	0.00	0.00	0.14	0.12	0.01	0.21	0.04	0.03
	13-14	1.029	0.00	0.00	0.00	0.00	2.19	0.17	0.11	0.02	0.30	0.00	1.20
	Average	1.071	0.54	0.00	0.00	0.00	1.96	0.10	0.10	0.14	0.25	0.01	1.41
5	**11-12**	1.090	0.38	0.00	1.15	0.00	0.00	0.00	0.42	0.00	0.18	0.09	0.53
	12-13	1.069	0.00	0.00	0.00	0.00	0.00	0.17	0.15	0.01	0.27	0.06	0.05
	13-14	0.998*	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.06	0.25	0.00
	Average	1.052	0.13	0.00	0.38	0.00	0.00	0.17	0.19	0.00	0.17	0.13	0.19
6	**11-12**	1.120	2.58	2.12	0.00	0.00	0.00	0.00	0.00	0.40	0.21	0.04	1.99
	12-13	1.001	0.00	0.00	0.29	0.00	0.00	0.00	0.29	0.00	0.00	0.18	0.04
	13-14	0.982*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.20	0.11	1.25
	Average	1.034	0.86	0.71	0.10	0.00	0.00	0.00	0.10	0.24	0.14	0.11	1.10

7	**11-12**	1.119	2.15	1.07	0.00	0.00	0.00	0.00	0.00	0.51	0.25	0.06	0.71
	12-13	1.013	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.01	0.23	0.07	0.04
	13-14	1.078	0.00	0.00	0.00	0.00	0.00	0.14	0.08	0.06	0.17	0.10	1.43
	Average	1.070	0.72	0.36	0.00	0.00	0.00	0.10	0.07	0.19	0.22	0.08	0.73
8	**11-12**	1.056	0.00	0.15	0.00	0.00	0.00	0.25	0.00	0.03	0.15	0.08	0.49
	12-13	1.031	0.00	0.00	0.00	0.00	0.00	0.12	0.17	0.02	0.23	0.07	0.04
	13-14	1.076	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.28	0.17	0.10	1.18
	Average	1.054	0.00	0.09	0.00	0.00	0.00	0.12	0.06	0.11	0.18	0.08	0.57
9	**11-12**	1.065	2.93	1.82	0.00	0.00	0.00	0.00	0.00	0.40	0.20	0.04	0.81
	12-13	1.054	0.00	0.00	0.00	0.00	0.00	0.15	0.14	0.01	0.24	0.05	0.04
	13-14	1.103	0.00	0.00	0.00	0.00	16.80	0.19	0.13	0.00	0.30	0.00	1.20
	Average	1.074	0.98	0.61	0.00	0.00	5.60	0.11	0.10	0.14	0.25	0.03	0.68
10	**11-12**	0.995*	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.20	0.25	0.00	0.00
	12-13	1.042	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.01	0.23	0.05	0.03
	13-14	0.993*	0.00	0.00	0.00	0.00	0.00	0.28	0.01	0.00	0.07	0.20	0.00
	Average	1.010	0.00	0.00	0.00	0.00	0.00	0.20	0.05	0.07	0.18	0.08	0.01
11	**11-12**	1.066	0.00	0.66	0.27	0.00	0.00	0.32	0.00	0.00	0.18	0.10	0.10
	12-13	1.079	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.01	0.23	0.05	0.04
	13-14	1.004	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.03	0.26	0.01	1.15
	Average	1.050	0.00	0.22	0.09	0.00	0.00	0.21	0.08	0.01	0.22	0.05	0.43
12	**11-12**	1.101	0.79	0.31	0.00	0.00	0.00	0.00	0.00	0.42	0.21	0.05	0.45
	12-13	1.065	0.00	0.00	0.00	0.00	0.00	0.13	0.18	0.02	0.25	0.07	0.04
	13-14	1.087	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.01	0.08	0.21	1.26
	Average	1.084	0.26	0.10	0.00	0.00	0.00	0.15	0.06	0.15	0.18	0.11	0.58
13	**11-12**	1.085	1.10	0.00	2.14	0.00	0.00	0.00	0.46	0.00	0.19	0.10	0.17
	12-13	1.031	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.01	0.23	0.05	0.04
	13-14	1.137	0.00	0.00	0.00	0.00	0.00	0.17	0.11	0.04	0.30	0.01	1.29
	Average	1.084	0.37	0.00	0.71	0.00	0.00	0.11	0.23	0.02	0.24	0.05	0.50

14	**11-12**	1.017	3.47	0.00	1.55	0.00	3.85	0.00	0.46	0.00	0.27	0.00	2.68
	12-13	1.033	0.00	0.00	0.00	0.00	0.00	0.16	0.14	0.01	0.24	0.05	0.04
	13-14	1.004	0.00	0.00	0.00	0.00	0.00	0.15	0.10	0.03	0.25	0.01	1.17
	Average	1.018	1.16	0.00	0.52	0.00	1.28	0.10	0.23	0.01	0.25	0.02	1.30
15	**11-12**	1.023	2.27	2.88	0.00	0.00	0.00	0.00	0.00	0.47	0.24	0.05	0.89
	12-13	1.063	0.00	0.00	0.00	0.00	0.00	0.15	0.14	0.01	0.24	0.05	0.04
	13-14	1.170	0.15	0.00	0.00	0.00	0.00	0.00	0.09	0.26	0.27	0.06	1.77
	Average	1.085	0.81	0.96	0.00	0.00	0.00	0.05	0.08	0.25	0.25	0.05	0.90
16	**11-12**	1.028	0.00	2.55	0.00	0.00	6.75	0.01	0.00	0.39	0.24	0.00	2.24
	12-13	1.046	0.00	0.00	0.00	0.00	0.00	0.16	0.10	0.00	0.26	0.00	0.04
	13-14	0.976*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.20	0.05	0.00
	Average	1.017	0.00	0.85	0.00	0.00	2.25	0.06	0.03	0.22	0.23	0.02	0.76
17	**11-12**	1.059	0.00	0.95	0.00	0.00	3.17	0.01	0.00	0.40	0.24	0.00	3.94
	12-13	1.003	0.00	0.00	0.00	0.00	1.18	0.18	0.10	0.00	0.26	0.00	0.03
	13-14	1.013	2.15	0.14	0.00	0.00	0.00	0.00	0.00	0.28	0.18	0.10	3.02
	Average	1.025	0.72	0.36	0.00	0.00	1.45	0.06	0.03	0.23	0.23	0.03	2.33
18	**11-12**	1.039	0.00	0.69	1.80	0.00	4.21	0.38	0.00	0.00	0.30	0.00	1.13
	12-13	1.019	0.08	0.01	0.00	0.00	0.00	0.15	0.13	0.01	0.23	0.05	0.04
	13-14	1.005	1.05	0.00	0.00	0.00	0.00	0.00	0.04	0.20	0.19	0.05	1.84
	Average	1.021	0.38	0.23	0.60	0.00	1.40	0.18	0.06	0.07	0.24	0.03	1.01
19	**11-12**	0.985*	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.17	0.09	6.06
	12-13	1.057	0.00	0.00	0.00	0.00	5.29	0.19	0.10	0.00	0.27	0.00	0.04
	13-14	1.126	0.00	0.00	0.41	3.45	0.00	0.14	0.20	0.00	0.00	0.32	1.68
	Average	1.056	0.00	0.00	0.14	1.15	1.76	0.21	0.10	0.00	0.15	0.14	2.59
20	**11-12**	0.993*	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.04	0.17	0.10	0.13
	12-13	0.991*	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.08	0.29	0.00	0.00
	13-14	1.044	0.00	0.00	0.00	0.00	0.00	0.22	0.02	0.10	0.21	0.12	1.55
	Average	1.009	0.00	0.00	0.00	0.00	0.00	0.24	0.01	0.07	0.22	0.07	0.56

21	**11-12**	1.067	1.17	1.70	0.00	0.00	0.00	0.00	0.00	0.42	0.17	0.09	0.65
	12-13	0.976*	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.16	0.21	0.08	0.00
	13-14	1.029	0.00	0.00	0.00	0.00	0.00	0.14	0.09	0.03	0.24	0.01	0.92
	Average	1.024	0.39	0.57	0.00	0.00	0.00	0.05	0.08	0.20	0.20	0.06	0.52
22	**11-12**	1.076	2.90	0.00	0.75	0.00	15.51	0.00	0.44	0.00	0.26	0.00	1.23
	12-13	1.029	0.00	0.00	0.00	0.00	0.00	0.12	0.17	0.02	0.23	0.07	0.04
	13-14	0.936*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.26	0.00
	Average	1.014	0.97	0.00	0.25	0.00	5.17	0.04	0.20	0.10	0.16	0.11	0.42
23	**11-12**	1.083	0.00	0.97	0.00	0.00	8.28	0.01	0.00	0.41	0.24	0.00	3.97
	12-13	0.993*	0.00	0.00	0.00	0.00	0.00	0.15	0.13	0.00	0.24	0.04	0.00
	13-14	0.889*	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.15	0.00	0.29	0.00
	Average	0.988*	0.00	0.32	0.00	0.00	2.76	0.05	0.10	0.19	0.16	0.11	1.32
24	**11-12**	0.903*	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.29	0.00
	12-13	1.007	0.00	0.00	0.00	0.00	0.00	0.14	0.13	0.01	0.22	0.06	0.04
	13-14	1.024	2.83	0.00	0.00	0.00	0.00	0.00	0.06	0.25	0.21	0.10	3.38
	Average	0.978*	0.94	0.00	0.00	0.00	0.00	0.16	0.06	0.25	0.14	0.15	1.14
Average of academic courses	**11-12**	1.052	1.13	0.70	0.33	0.00	1.89	0.08	0.09	0.22	0.21	0.06	1.58
	12-13	1.020	0.00	0.00	0.02	0.00	0.32	0.13	0.13	0.05	0.23	0.06	0.03
	13-14	1.028	0.01	0.00	0.00	0.00	0.02	0.12	0.06	0.12	0.17	0.11	1.12
	Average	1.033	0.38	0.23	0.12	0.00	0.74	0.11	0.10	0.13	0.20	0.08	0.91

I_1: Satisfaction with their teacher; I_2: Quality of materials; I_3: Diversity of materials; Context variables (I_4: Socio-economic and cultural level; I_5: Previous education). O_1: Level of satisfaction with the course; O_2: Academic results
The column three indicates the level of efficiency of each group. DMUs with values greater to the unit are inefficient; equal to the unit are efficient; and lower to the unit are super-efficient (*).